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Studies on Sanitizing Methods for Use in Poultry Processing[1]

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CONTENTS

SUMMARY

Five sanitizing methods were studied under commercial conditions to determine their effectiveness in decreasing bacteria on equipment and poultry during processing.

Inplant chlorination at 10, 20, and 45 parts per million (p. p. m.) concentrations in processing water was shown to be an exceptionally effective, overall means for decreasing the bacterial counts. It lowered the counts on equipment and on poultry carcasses, eliminated slime, corrosion, and plant odors, cleared corroded pipes and nozzles, and reduced cleanup time and labor by more than 33 percent.

Chlorinated snow did not prove to be any more effective as a sanitizing agent than did snow made from plain water.

Mechanical washing after evisceration proved to be very effective for producing visibly cleaner, less-contaminated processed poultry.

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[1] This report covers a part of a research study directed toward the solution of technical problems under commercial plant operating conditions. Although the study was made by the Poultry Branch of the Production and Marketing Administration, the report is being issued by the Agricultural Marketing Service, which is now responsible for the work. The work was carried on under authority of the Agricultural Marketing Act of 1946 (RMA, Title II).

Acknowledgment is made for the suggestions and assistance of Dr. Millard F. Gunderson, of the Nebraska College of Medicine, and Dr. Lyle L. Davis, of the Marketing Research Division, AMS, USDA. Credit is also due Swanson & Sons, Wallace & Tiernan Co., Inc., the Gordon Johnson Co., Washington Laboratories, Inc., and the Pasteuray Corp. for materials, facilities, and assistance in carrying out the work.

[2] Resigned.

259044°—54——1

The washing also completely eliminated the occurrence of at least one visibly dirty carcass in approximately every 10 processed birds as occurred when spray action alone was used.

The dipping of processed poultry in a chemical sanitizer was shown to be a promising method for use after evisceration. More research will be needed to develop fast-acting, low-cost, nontoxic germicidal chemicals for use as dips.

Ultraviolet treatment of poultry parts just before packaging reduced the numbers of bacteria on the surface of the parts. This method shows promise as a sanitizing adjunct for packaging line use, where a dry form of germicidal treatment is needed.

INTRODUCTION

Widespread research has established the fact that the quality of a food product depends directly on the sanitary practices of the plant in which the product is processed. Products that have been excessively contaminated with filth and bacteria are considered to be of low sanitary quality, and such products may be classed as adulterated under provisions of the Federal Food, Drug, and Cosmetic Act. High sanitary quality results in products that are cleaner, more healthful, of better appearance and better keeping quality and potentially of greater market value than products that are lacking in sanitary quality.

It is especially important that the poultry processor have the best possible sanitation in his plant. The birds naturally carry great numbers of bacteria to the processing plant on their feathers and feet and in the intestinal tract. Unless strict sanitary measures are observed, such bacteria increase quickly and are spread during processing to the skin and flesh of the carcasses.

In an effort to improve existing conditions, an exploratory research project was conducted. It was designed to determine how, where, and why the sanitary quality of poultry changes during processing, and how effective certain sanitizing methods would be for improving the sanitary quality of processed poultry and the sanitation of the plant.

Gunderson et al. (*16*) [3] found that most commercially eviscerated poultry had a very heavy surface load of micro-organisms, with coliform organisms especially prevalent. He also pointed out that it was necessary to count the microbial population on equipment and product in order to determine the real sanitary status. Edwards (*8*), Barnes (*4*), and Helvig and Hart (*21*) pointed out the possibilities of processed poultry as a source of infection for man. Lochhead and Landerkin (*26*) and Ayres et al. (*3*) found that spoilage of chicken carcasses was caused by a bacterial slime and odor formation on the surface of the skin and flesh of processed birds. Ayres et al. (*3*) added the statement, "Birds prepared with sound sanitary practice invariably had a good keeping time, while chickens processed by unsanitary methods were shown to develop slime quickly."

In the light of research findings, the processing of poultry under conditions which would assure high sanitary quality would minimize

[3] Italic numbers in parentheses refer to Literature Cited, p. 29.

any potential dangers to public health and would increase savings to processors and handlers by reducing spoilage losses.

Some sanitizing methods that have been reported as successful in plants processing other foods were considered for testing in poultry plants. The use of breakpoint chlorination had been reported (*2*, *5*, *17*, *19*, *22*, *25*, *31*, *34*) as a valuable adjunct to other sanitary measures in fish-processing plants, vegetable canneries, dehydrating plants, and food-freezing plants. Previous research showed that chlorine effectively lowered bacterial numbers on product and equipment (*3*, *12*, *20*, *22*, *25*, *31*), minimized slime and odor (*9*, *18*, *19*, *20*), and prevented scale formation in pipes and on equipment (*9*).

Successful use of germicidal chemicals for use as dips for lowering bacterial contamination on foodstuffs has been reported (*6*, *14*, *24*, *35*).

Many reports have been made of the germicidal action of ultraviolet rays and of the use of these rays for reducing the numbers of microorganisms on meats and other foodstuffs (*10*, *11*, *23*, *27*, *28*, *30*, *33*).

EXPERIMENTAL PROCEDURE

The research was carried out under plant-operating conditions, so that direct application of any improvements resulting from the experimental work could be made in other plants. The operations of a number of poultry-processing plants were observed to determine the degrees of sanitation normally obtained. These observations were used as a basis for selecting one plant which appeared to follow the sanitation practices most commonly used in commercial plants. The mobile laboratory of the Research Division of the Poultry Branch, Production and Marketing Administration, was then taken to the selected plant.

At the selected plant, the actual work was directed largely toward a study of the surface areas of poultry carcasses and equipment. It was observed that certain equipment or handling techniques could spread contaminating materials arising from flora present on the skin of the live bird, mud and filth from the bird's feet, crop material, and feces forced from the bird during processing. Surface studies, therefore, indicated the extent and reasons for the surface contamination. General observations of occurrences of slime formation, off-odors, and sediment collection were noted. Also noted were the labor, time, and procedures necessary for good cleanup.

To determine the effect of the different operations, equipment, and procedures, surface areas of poultry carcasses and equipment were bacteriologically sampled at previously selected stations. Carcasses on the dressing line were sampled at the stations listed in the following tabulation and indicated in figure 1:

Station	*Place*
D–1	After the first rough picker.
D–2	After the finish picker.
D–3	Before the mechanical washer.
D–4	After the mechanical washer.

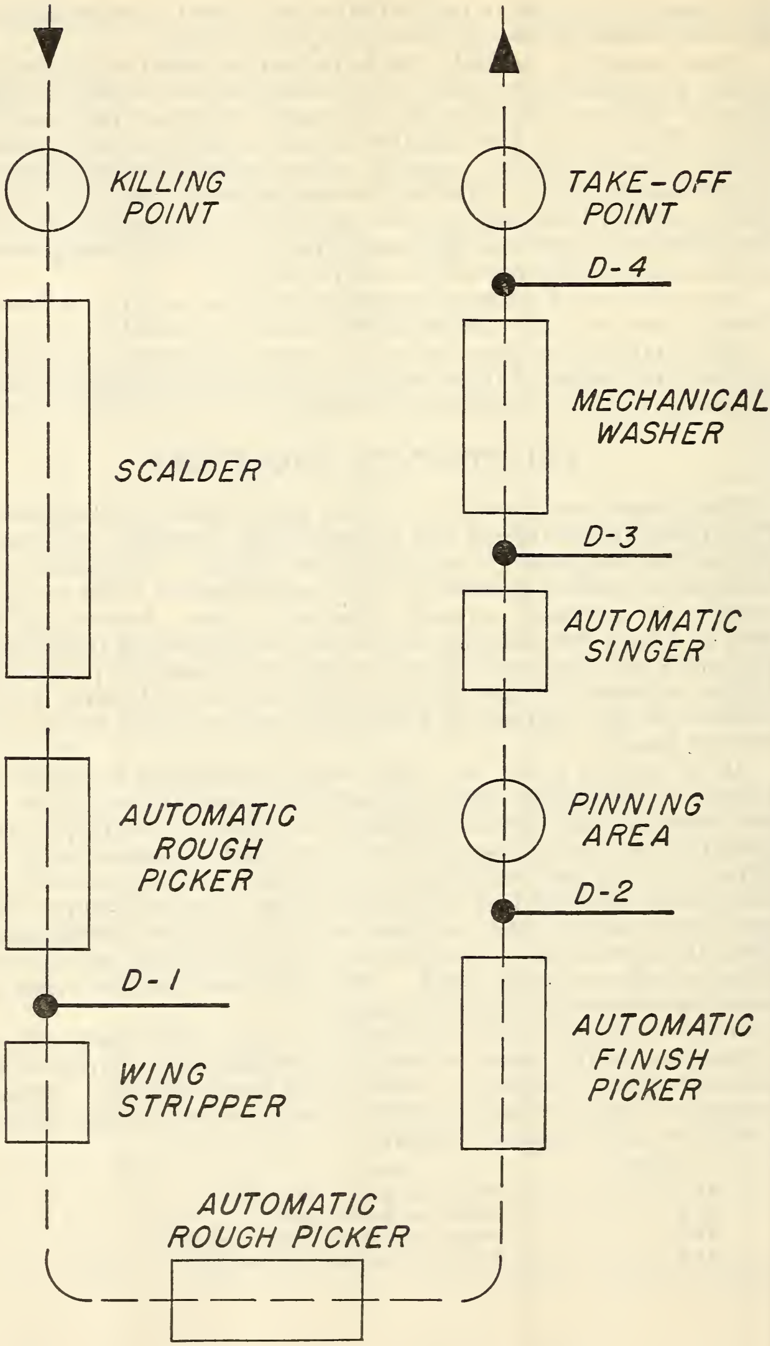

FIGURE 1.—Flow diagram showing the order of dressing line operations and the sampling stations.

The dressed birds were sampled along the eviscerating line at the stations listed in the following tabulation and indicated in figure 2:

Station	*Place*
E–1	Before the singer.
E–2	After the singer.
E–3	After the mechanical washer.
E–4	After the check pinning.
E–5	After the crop removal.
E–6	After vent cutting.
E–7	After evisceration and inspection.
E–8	Before the inside washer.
E–9	After the inside washer.
E–10	Before the outside washer.
E–11	After the outside washer.
E–12	At the end of the eviscerating line.

The pieces of equipment which appeared to be potential sources of bacterial contamination for the carcasses were swabbed at stations listed in the following tabulation and indicated in figure 2:

Station	*Place*
S–1	The trough surface where crops and vents were cut.
S–2	The apron leading to the inspection table.
S–3	The inspection table pans.
S–4	The trough surface where lungs and kidneys were removed.
S–5	The tile surface of the inside-bird washer.
S–6	The table surface at the point where improperly finished birds were removed from the line and refinished.
S–7	The trough surface just before the outside washer.
S–8	The inner tile surface of the outside spray washer.

Samples were taken also of processing water discharged from the mechanical washer at station L–1, the inside washer at station L–2, and the outside washer at station L–3, figure 2. Samples were pipetted from the water as it discharged from the equipment outlets.

The eviscerated birds along the transfer operations—the operations falling between the last eviscerating line operations and the first operation of the segmenting and packaging line—were sampled at the stations listed in the following tabulation and indicated in figure 3:

Station	*Place*
T–1	Immediately after the removal from the eviscerating line, before the birds were weighed on a platform scale for sizing by weight.
T–2	After weighing, before being put into the chilling tanks.
T–3	After chilling.
T–4	After the handling necessary to remove the bird from the chilling tank and hang it on segmenting and packaging line conveyor.

The chilled processed birds on the segmenting and packaging line were sampled at the stations indicated in figure 4.

Five separate runs of taking samples were made. Each run represented a different lot of birds. Within a lot, the same birds were followed and sampled from beginning to end of a particular line whenever possible.

Along the dressing and eviscerating line and at the transfer operations, the carcasses and equipment were sampled by the swab method reported by Ayres et al. (*3*), with modifications. Sterile cotton-tipped swabs were used to adsorb the bacteria from areas kept constant

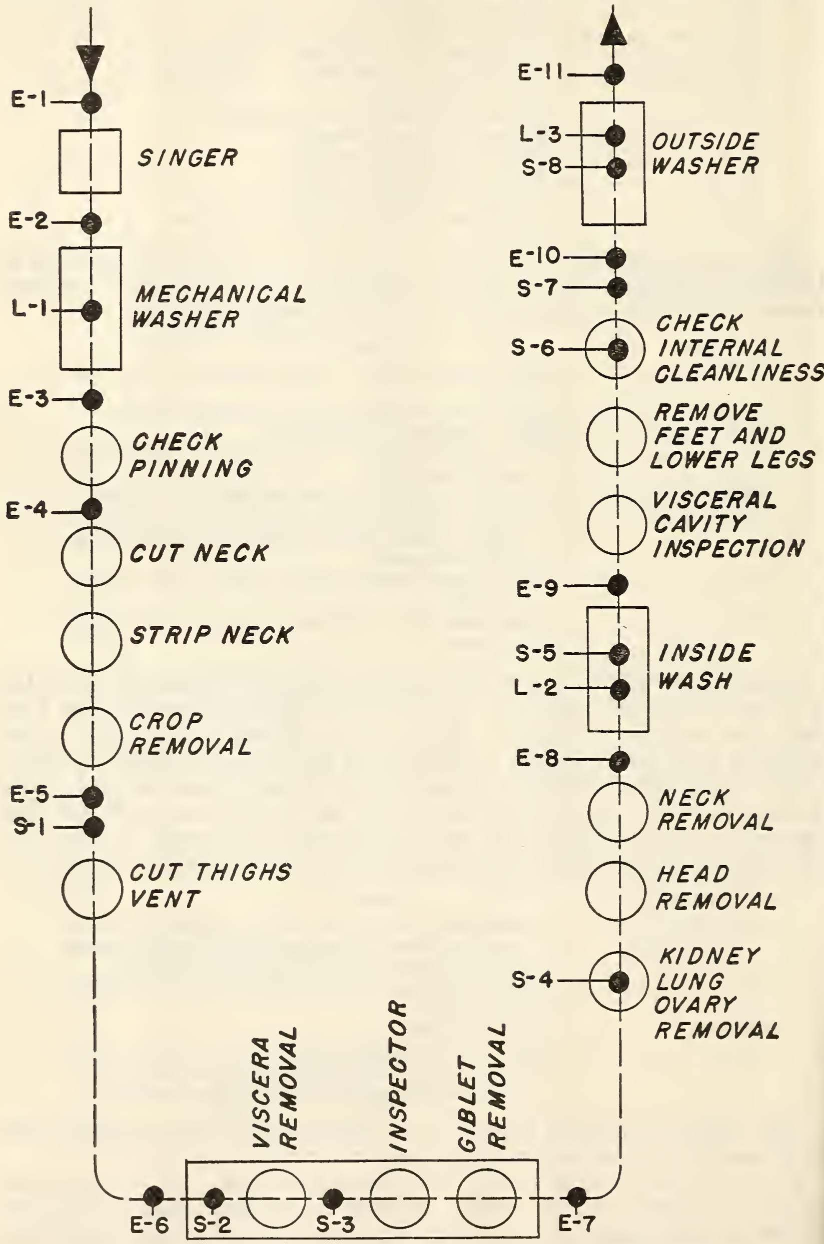

FIGURE 2.—Flow diagram showing the order of eviscerating line operations and the sampling stations.

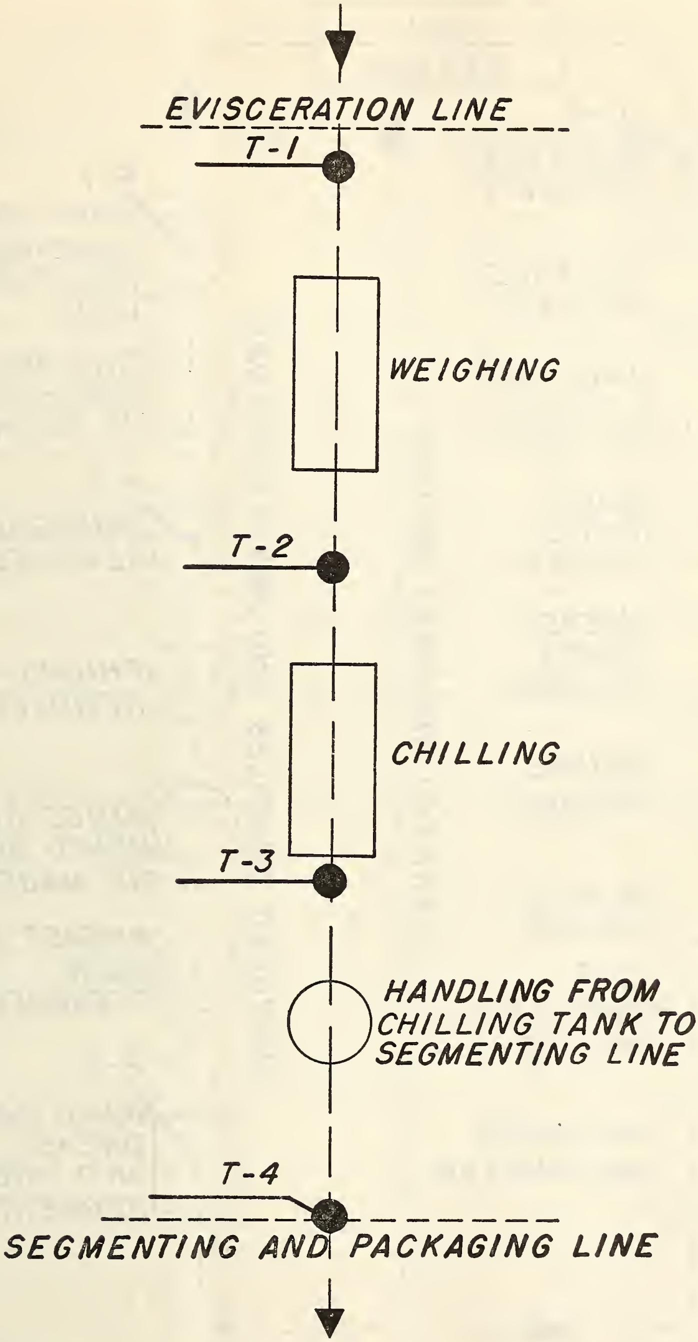

FIGURE 3.—Flow diagram showing the order of transfer operations and the sampling stations.

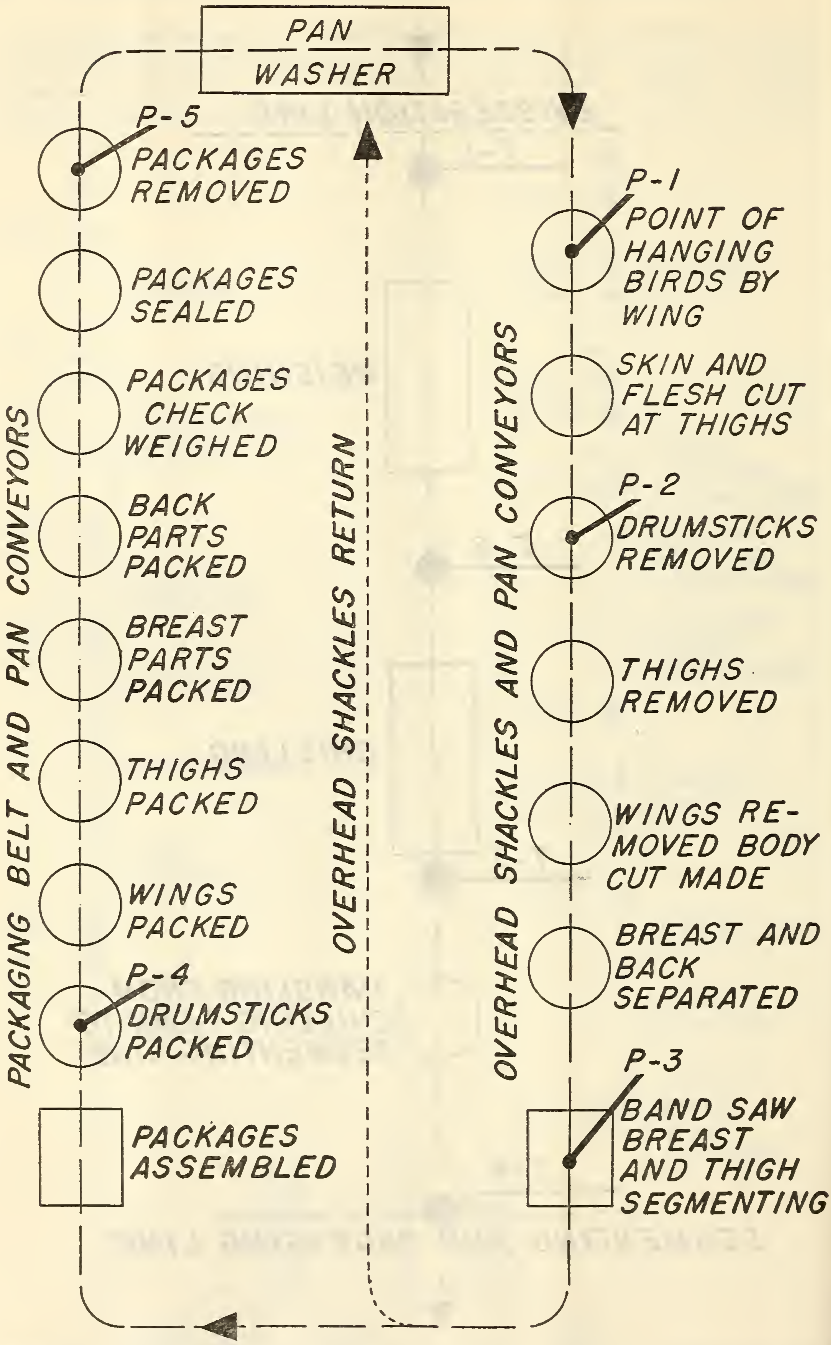

FIGURE 4.—Flow diagram showing the order of cutting-up and packaging line operations and the sampling stations.

by a template. The templates, waxed sanitary gaskets such as are used in 2-inch sanitary pipe fittings, were 3.9 centimeters in diameter and exposed an area of 12 square centimeters. After the exposed area had been swabbed, the cotton tips were broken off into 99 milliliters of sterile saline. Serial dilutions were made and plated on tryptone glucose extract agar according to the standard plate method as reported in Standard Methods for the Examination of Dairy Products (*1*). Swabbing in each case was done on previously selected areas of the carcass and equipment, and according to a set pattern to assure identical swabbing in the different runs and to prevent repeat swabbing of the same area.

For "cutup" poultry, a new method was developed to sample the whole part. It was necessary to sample the whole part rather than any particular area of the part because of the surface conditions created by the cutting operations. Parts of the cutup poultry were aseptically placed into plastic bags. Water which had been sterilized was siphoned into the bags in quantities—depending on the size of the sample part—of 200, 500, or 1,000 milliliters. Bags were shaken 50 times and aliquot parts of the water were pipetted into dilution bottles. Serial dilutions were made and plated as described above.

The procedure used in making determinations along the segmenting and packaging line differed from those along the other lines because of the nature of the operations and the sampling method used. Conditions along this line were determined by two tests. In the first test, bacterial counts on carcasses at the beginning of the line were compared with counts on poultry parts in the package at the end of the line. Randomly selected whole carcasses were aseptically removed from the conveyor at station P–1 of the cutting line, and packages of segmented carcasses from the same lot were removed from the packaging line at station P–4. The whole carcasses were aseptically cut up into the same numbers of parts as those that had been packaged by the regular plant employees. Pairs of parts—2 drumsticks, 2 thighs, 2 wings, 2 breasts, and 2 parts of the back—were placed into individual plastic bags and sampled as described above.

In the second test, parts for sampling were taken, beginning at station P–2, through the operations to station P–5. As the hanging carcass moved along the line, each pair of parts—that is, drumsticks, thighs, wings, breasts, and parts of the back—that was cut away was separated by the operator; one part was put into a plastic sampling bag and the other part was placed on the conveyor pan. The nonbagged parts of each processed bird were kept together on the conveyor pan and packaged, as is ordinarily done, into the same package at stations P–4 through P–5. All pieces of the two groups were sampled by the shake method.

Testing of sanitizing methods was begun with the installation of chlorination equipment. A gaseous-type chlorinator was installed along one of the two existing water systems in the plant so that water used for processing, cleaning, and flushing was chlorinated at any predetermined level of chlorine concentration. Tests were run with the chlorinating apparatus set to maintain levels of 10, 20, and 45 parts per million of free chlorine in water. Adjustment to new levels was always made 24 hours before the test. Samples from processed birds and equipment were taken at the same stations and in the same way as those in the first tests when no chlorine was used.

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Since artificial snow was manufactured in the plant for use in cooling tanks to chill poultry carcasses, a test was performed to determine the properties of snow as a carrier of chlorine and its value, when made of chlorinated water, as a sanitizing agent for use in cooling tanks, and as a sanitizing, cooling agent for ice packing.

The occluding capacity of snow for chlorine was tested. Tanks of freshly made snow were analyzed over a 24-hour period. The orthotolidine comparator (*19*) was used to measure the chlorine concentration. Readings were obtained for samples of snow taken from the top, the middle, and the bottom of tanks, and for samples of water collected on the bottoms of the tanks.

The sanitizing value of snow made from chlorinated water was tested bacteriologically by comparing the changes in surface counts of bacteria on processed chickens held in chlorinated and plain snow. Both eviscerated and noneviscerated groups of carcasses were used in each run. Each group within a run included 40 birds, 20 of which had been processed under nonchlorinated water conditions; the other 20 were processed under chlorinated water conditions. Each set of 20 processed birds was divided into half—10 were held in chlorinated snow and 10 in plain snow. The processed birds were swab sampled and packed with snow in 55-gallon drums. The drums were held at 35° F. Snow was added when needed. After 96 hours the processed birds were again swab sampled. The test was repeated four times.

It was found that the spray washer, ordinarily the last operation on eviscerating lines, did not efficiently wash the processed birds. Many carcasses arrived at the takeoff point with highly contaminated particles of crop material and feces still adhering to the outer surfaces. A scrubbing action had to be included with the spray to accomplish effective washing.

A machine that incorporated both spray and scrubbing actions was being used on the dressing line and at the beginning of the eviscerating line to help remove the outer cuticle from New York dressed birds. An experiment was performed to test the effectiveness of this mechanical washer when used as the last operation along the eviscerating line.

Two models of the mechanical washer were used. One model was identical with washers already in use in the plant. The other washer was an improved model designed as a result of the test with the models already in the plant. The improved model featured in its design a number of powerful sprays which shot water into the body cavity of the eviscerated bird for inside washing.

Carcasses were selected for sampling both randomly and by inspection. Those selected by inspection were chosen because of visible contamination. All sample carcasses were: Hung by a wing to prevent skin tears, sampled by the swab technique, passed through the mechanical washer, sampled again, and inspected for visible filth. Other carcasses from the same lots were passed through the spray washer and sampled to provide results for comparison. The carcasses passed through the improved model washer were swab sampled inside as well as outside.

Germicidal chemicals have been used in food industries for many purposes. Of interest to this work were reports of the use of certain chemical germicides into which foods were dipped (*6*, *14*, *24*, *35*), thus obtaining bactericidal treatment.

Logically, a proper chemical could be incorporated into poultry processing as a dip, just before packaging, to effect a high degree of sanitary quality in the packaged product. Such a chemical must be nontoxic to humans, nondetrimental to carcass finish, and effective in reducing the bacteria on the carcass surfaces.

A commercial compound which contained fumaric and benzoic acids and which had been recommended for use on foodstuffs was employed. The test considerations were the effectiveness of bacterial reduction, the effect on carcass finish, and the relative cost of the chemical.

A solution—1,000 parts per million, by weight—of the chemical was prepared and used according to the manufacturer's directions. Carcasses of broiler chickens were removed at the end of the eviscerating line, before the final washing operation. They were tagged, swabbed, and placed into containers of the dip solution. The carcasses were removed from the solution after 10 minutes, swab sampled again, and inspected for effects detrimental to the skin finish.

Ultraviolet radiation was reported to have been used with success in the red-meat industry to kill micro-organisms on the surface of meats (*10*, *27*, *28*). In view of its apparent lethality to micro-organisms, the ultraviolet radiation was believed to possess possibilities as an adjunct to other sanitation practices for producing a high degree of sanitary quality in poultry. A sanitizing medium of this type would be valuable at operations such as those of the packaging line, where a dry form of germicidal action is needed for killing bacteria on equipment and on the product.

A series of tests was performed using an experimental ultraviolet-ray machine. The machine was designed to carry poultry parts on hooks along a conveyor between five banks of ultraviolet tubes, three tubes to a bank. The conveyor speed was adjustable for exposure times falling between 6 and 13 minutes. Tubes were used in sets, either all nonozone or all ozone producing. Each tube emitted a ray which had a wave length of 2,537 microns and a power of 2,800 microwatts at 3 inches' distance.

To determine bacterial-count changes, chicken carcasses were taken from the eviscerating line before the final wash. They were aseptically halved and one-half of each chicken was sampled immediately by the shake method to get the initial count. The remaining halves were treated by ultraviolet ray emitted by nonozone tubes. These treated halves were exposed for different times—13, 26, and 39 minutes. After their respective exposures, the halves were sampled by the shake method. The test was repeated with ozone-producing tubes.

A test was made to determine the visible effects of radiation on skin and flesh of processed chickens for different exposure times. Halves of fowls were passed through the machine for a total of 60 minutes After each 6-minute interval, the halves were inspected for changes.

A second test was run in which comparison of the effects of different exposure times was made. Ten halves of fowl were passed through the machine. One of the halves was removed after each 6-minute interval. Companion halves were withheld from treatment for use as controls. The controls and the halves from each time-interval exposure were inspected and compared for visible changes. The test was repeated with ozone tubes.

A third test was performed to test the possibility of delayed reactions that would be detrimental to the skin and flesh of the car-

casses. Four sets of three fowl halves were exposed to the radiation for 13, 26, 39, and 52 minutes. Companion halves were withheld for control purposes. All the halves were packaged and stored at 38° F. After 48 hours the halves were inspected for changes.

A fourth test was performed to compare differences between carcasses of broilers and fowl that had been exposed to radiation. Halves of both types of carcasses were hung alternately on the conveyor and were exposed for 120 minutes. At each 10-minute interval they were inspected for changes.

A fifth test determined the visible effects of ultraviolet radiation on blood and freshly cut flesh. Pieces of breast, thigh, and leg tissue were cut and hung on the conveyor. Blood was collected from freshly stuck chickens and spread in a thin layer on petri plates. The plates were hung on the conveyor for exposure. Both flesh and blood were exposed for 30 minutes and then inspected for changes.

RESULTS AND DISCUSSION

Inplant Chlorination

Data reported for the dressing line include average bacterial counts on processed chickens when no chlorine was used and when 10 and 20 parts per million of residual chlorine were contained in the processing water (table 1).

The levels of contamination at station D–1, immediately after the first feather-removal operation, were lower with chlorine concentrations than when no chlorine was used. The bacterial count was somewhat higher at 20 p. p. m. than at 10 p. p. m., but this is understandable, because the experiments were not performed at the same time nor on the same lots of processed chickens. The higher bacterial count was also attributed to the fact that at station D–1, in processing, the feathers, filth, and other organic matter utilized chlorine very quickly. As the carcass progressed through the dressing operations, the automatic finish picker (D–2) was responsible for a great increase in contamination on the carcass. Investigation in search of the cause revealed that the water-supply pipe to the machine was of smaller diameter than that recommended by the manufacturer. As a consequence, the water sprays that washed the rubber fingers of the picker machine were not effective for good cleansing action. As chicken carcasses passed through the machine, the fingers became grossly contaminated and spread bacteria to the succeeding carcasses. This condition was corrected by the plant at a later date. Results from a test made after the condition had been corrected showed that the bacterial count fell from 45,000 to 31,000 bacteria per square centimeter.

Table 1.—*Average bacterial counts on the surface of chicken carcasses at specified stations along the dressing line when processing water contained chlorine concentrations of 0, 10, and 20 parts per million*

Station	Bacterial count per square centimeter with chlorine concentration of—		
	0 p. p. m.	10 p. p. m.	20 p. p. m.
	Number	*Number*	*Number*
D–1	380, 000	42, 000	70, 000
D–2	625, 000	240, 000	204, 000
D–3	208, 000	117, 000	37, 000
D–4	137, 000	85, 000	22, 000

The bacterial count dropped appreciably at station D–3 after the carcasses had passed through the automatic gas singer, and the count decreased again as the carcasses passed through the mechanical washer, as shown by the sampling at D–4. The bacterial counts at D–4 were clearly different in the desired direction—137,000 without the use of chlorine, or for 0 p. p. m.; 85,000 for 10 p. p. m. of chlorine; and 22,000 for 20 p. p. m. of chlorine in the processing water. These results indicate that chlorination would be of bactericidal value even under the adverse condition of rapid chlorine utilization. One operation, the finisher in the dressing line, was responsible for recontaminating the poultry carcasses to a level that prevented high sanitary quality of the New York dressed bird. The effects of the different chlorine concentrations at the four stations along the dressing line are shown graphically in figure 5.

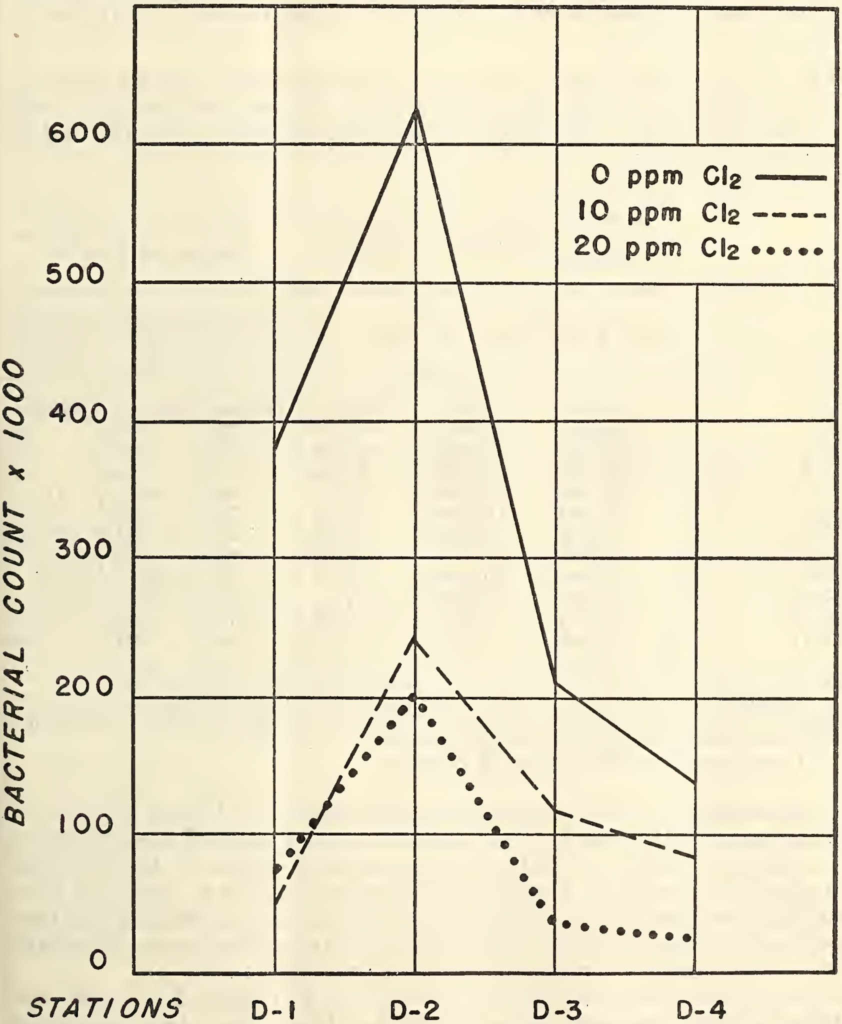

FIGURE 5.—Graphic comparison of average bacterial counts along the dressing line when chlorine concentrations of 0, 10, and 20 p. p. m. were used.

The data from similar tests along the eviscerating line at 0, 10, and 20 p. p. m. of residual chlorine in the processing water are shown in table 2. Counts of bacteria at each station represent averages of counts from 10 chicken carcasses sampled.

The sampling at station E–1 was performed immediately after chicken carcasses were hung on the eviscerating line conveyor. Bacterial counts at E–1 on all carcass samples were consistently lower than those on carcasses going into the chilling vats. At the time of testing at that point, confirmatory tests were not performed; however, tests later performed on the chilling of eviscerated birds proved that the chilling operation did lower the levels of contamination.

For the most part, the operations which immediately preceded those at stations E–2, E–5, E–7, E–8, and E–10 served to increase the bacterial count on the carcasses. In each case, though, the increment of count rise was smaller with increased concentrations of chlorine in the processing water.

TABLE 2.—*Average bacterial counts on chicken carcasses and percentages of difference at specified stations along the eviscerating line when processing water contained chlorine concentrations of 0, 10, and 20 parts per million*

Station	Bacterial count per square centimeter with chlorine concentration of—			Percentage difference between counts at—		
	0 p. p. m.	10 p. p. m.	20 p. p. m.	0 and 10 p. p. m.	0 and 20 p. p. m.	10 and 20 p. p. m.
	Number	*Number*	*Number*	*Percent*	*Percent*	*Percent*
E–1	140, 000	46, 000	6, 200	67	96	87
E–2	272, 000	36, 000	9, 000	87	97	75
E–3	30, 000	11, 000	2, 000	63	93	82
E–4	16, 500	11, 000	(1)	33	(1)	(1)
E–5	75, 000	18, 000	3, 700	76	95	79
E–6	9, 500	5, 000	6, 600	47	31	(2) 32
E–7	18, 000	7, 000	3, 900	61	78	44
E–8	19, 000	10, 000	(1)	47	(1)	(1)
E–9	14, 000	5, 000	(1)	64	(1)	(1)
E–10	83, 000	18, 000	3, 500	78	96	81
E–11	17, 000	7, 000	500	59	97	93

[1] Stations E–4, E–8, and E–9 were eliminated during the 20-p. p. m. test because the conveyor movement had been increased to a speed which did not allow time for effective sampling at these stations.

[2] Count greater at 20 p. p. m. of chlorine.

At station E–2, after the singeing, the reason for the rise in bacterial count was not determined. A plausible explanation of the differences in bacterial counts at stations E–1 and E–2 might be found in the method of sampling. The skin of carcasses at E–1 was very firm from chilling, whereas at E–2 the skin was loose from the heat it had been subjected to in singeing. It appeared that more effective swabbing was obtainable on loose than on very firm skin.

At station E–5, the rise in bacterial count resulted from crop material being smeared on the carcass by handling. The three operations preceding those at station E–5 were all performed above troughs

equipped with pipes for running water, but the water supply to the pipes was insufficient and the workers pushed material accumulating in the trough along by hand. At the same time they attempted to wash their hands and knives in the scarce supply of water, as no other means for washing had been provided. Evidently such weaknesses in operating practices were responsible for the increases in bacterial counts.

At station E–7, following the removal of viscera, and at station E–8, following removal of other parts, the bacterial counts increased. Each of the operations involved a good deal of handling with no provision for washing of hands, knives, or carcasses. The same conditions were true for the three operations preceding those at station E–10.

The above-mentioned considerations show very definitely that the operations which included no washing but entailed handling of the carcass and removal of highly contaminated parts, such as the crop and viscera, caused increases in the number of bacteria on chicken carcasses.

Of the stations which showed a decrease in bacterial count, stations E–3, E–9, and E–11 were most important. The significance of the lowered counts at these stations lies in the fact that the lowering resulted from washing operations in which substantial quantities of water were used. Station E–3 followed the mechanical washer, E–9 followed the inside washer, and E–11 followed the outside spray washer.

The overall count change between the first station (E–1) and the last station (E–11) showed that the eviscerating line operations effectively lowered the number of bacteria on surfaces of carcasses even when no chlorine was used. However, the following comparison shows that when the action of chlorine was combined with the decontaminating action of the operations, the resulting counts were much smaller than when no chlorine was used:

At 0 p. p. m., the count decreased from 140,000 to 17,000 bacteria per $cm.^2$
At 10 p. p. m., the count decreased from 46,000 to 7,000 bacteria per $cm.^2$
At 20 p. p. m., the count decreased from 6,200 to 500 bacteria per $cm.^2$

This desirable effect took place all along the line. The level of contamination was much lower at all stations when chlorine was used in the processing water than when no chlorine was used. Of special interest were the counts at station E–11, where, on the eviscerated bird, 17,000 bacteria remained at 0 p. p. m., 7,000 at 10 p. p. m., and 500 at 20 p. p. m. of free chlorine in the processing water.

Percentagewise, the differences at station E–11 are especially important. The percentage difference in bacterial counts between 0 and 10 p. p. m. was 59 percent; between 0 and 20 p. p. m., 97 percent; and between 10 and 20 p. p. m. the difference was 93 percent.

The large differences in final bacterial counts show clearly the important role that chlorination of the processing water played in producing eviscerated chickens of high sanitary quality as compared with those produced when chlorine was not used.

The effects of chlorine in the processing water along the eviscerating line may be observed in figure 6 in which the values shown in table 2 are presented graphically. The lines showing the changes in bacterial counts between stations give evidence that two desired effects were obtained from chlorine use: (1) Chlorine minimized the importance of any one station as a source for gross contamination, and (2),

chlorine use resulted in lower levels of contamination at all stations than when chlorine was not used, the lowest levels of contamination being at the highest chlorine concentrations.

Although the results of the runs at different concentrations were useful for comparison, the degree of effect was in question because the different runs were made at different times and on different lots of birds. To compare the effects of chlorine concentrations on bacterial counts of carcasses in the same lot, a test was performed at the last eviscerating line operation, station E–11.

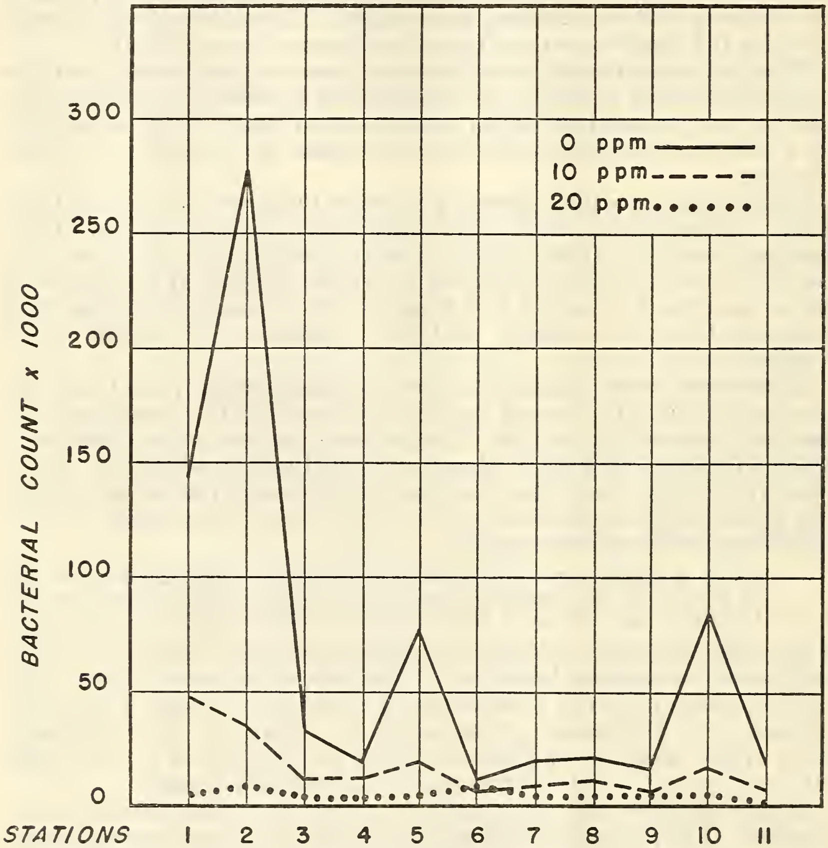

FIGURE 6.—Graphic comparison of average bacterial counts along the eviscerating line when chlorine concentrations of 0, 10, and 20 p. p. m. were used.

The chlorine concentration in the processing water was adjusted in sequence from a zero residual to 10, 20, and 45 p. p. m. Twenty clean-appearing carcasses, for each group that had been processed at a particular concentration from the point of killing, were selected at station E–11. Samples were taken with swabs, serial dilutions were made, and tryptone glucose agar plates were prepared and incubated.

The resulting counts for each carcass were averaged with others within a group, and comparisons of group averages were made (fig. 7).

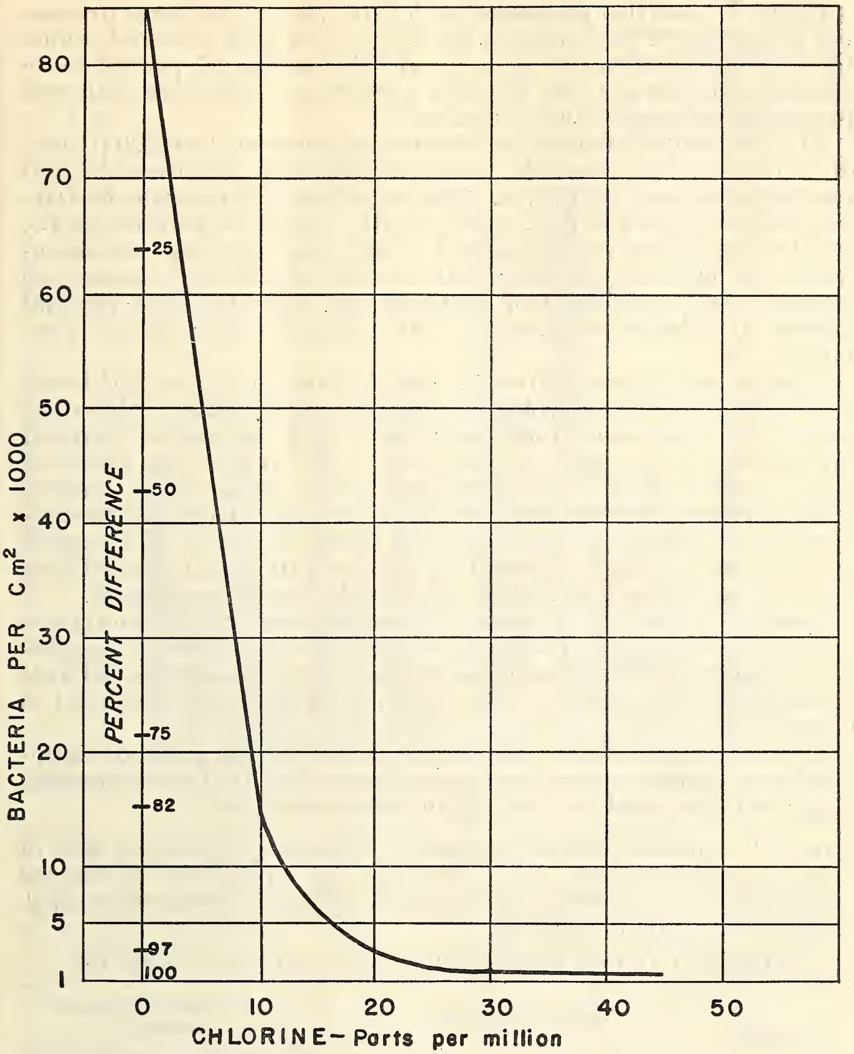

FIGURE 7.—Graphic comparison of average bacterial counts and percentage differences in counts when 0, 10, and 45 p. p. m. of chlorine were used

The action was not different from that observed in the earlier comparisons, except in the size of percentage differences.

In the comparison, the count representing 850,000 bacteria per square centimeter, without the use of chlorine, or for 0 p. p. m., was arbitrarily taken as being a 100-percent count. Counts for the other chlorine concentrations were plotted on the bacterial count scale, so that by reading along the inverted percentage scale the percentage difference between the count at 0 p. p. m. and the counts at 10, 20, and 45 p. p. m. of chlorine may be noted. The percentage differences so determined may be taken as a measure of the effectiveness of the different chlorine concentrations.

Figure 7 shows that processing with 10 p. p. m. of chlorine in processing water was 82 percent more effective in lowering bacterial counts than was no chlorine; 20 p. p. m. of chlorine was 97 percent more effective; and 45 p. p. m. was 98.5 percent more effective than was processing in water with no chlorine.

The percentage difference in effectiveness between 10 and 20 p. p. m. of chlorine was appreciable, and this difference constitutes a good reason for the use of 20 p. p. m. The percentage difference in effectiveness between 20 and 45 p. p. m. was small. The small percentage, 1.5, of additional effectiveness gained by more than doubling the concentration of chlorine, together with factors of cost and comfort to workers, who complained of irritated eyes when the high residual content of chlorine was used, would make the use of 45 p. p. m. inadvisable.

Other beneficial results from the use of 10 and 20 p. p. m. of chlorine in processing water were observed throughout the plant. Slime was completely eliminated from floors, walls, and inaccessible parts of equipment. Odors which accompany slime, and which permeate many poultry plants, were completely gone. Pipes, spray nozzles, and equipment surfaces were completely freed of manganese precipitate that had plagued that particular plant. Also figures compiled by the plant manager showed that the cleanup period was reduced by 33 percent after installation of the chlorinating equipment.

Data from sampling of bacteria on the eviscerating-line equipment and in water from the three washers are shown in table 3, together with percentage differences between the bacterial counts at different concentrations of chlorine. These data are graphically presented in figure 8.

From table 3 and figure 8, it may be noted that the pieces of equipment most highly contaminated were those which did not use running water and those used for washing the carcasses of birds.

TABLE 3.—*Average bacterial counts on surfaces of equipment and in processing water from the eviscerating line equipment at specified stations when processing water contained chlorine concentrations of 0, 10, and 20 parts per million*

BACTERIAL COUNT PER SQUARE CENTIMETER OF SURFACE

Station	Chlorine concentration of—			Percentage difference between—		
	0 p. p. m.	10 p. p. m.	20 p. p. m.	0 and 10 p. p. m.	0 and 20 p. p. m.	10 and 20 p. p. m.
	Number	*Number*	*Number*	*Percent*	*Percent*	*Percent*
S–1	6, 000	300	150	95	98	50
S–2	9, 000	4, 000	400	56	96	90
S–3	9, 500	350	300	96	97	14
S–4	45, 000	20, 000	550	56	99	97
S–5	1, 000, 000	500, 000	20, 000	50	98	96
S–6	2, 000, 000	700, 000	6, 000	65	99	99
S–7	4, 000	2, 000	400	50	90	80
S–8	20, 000	300	200	98	99	33
BACTERIAL COUNT PER MILLILITER OF WATER						
L–1	2, 500, 000	300, 000	6, 500	88	99	98
L–2	550, 000	45, 000	3, 000	92	99	93
L–3	300, 000	50, 000	2, 000	83	99	96

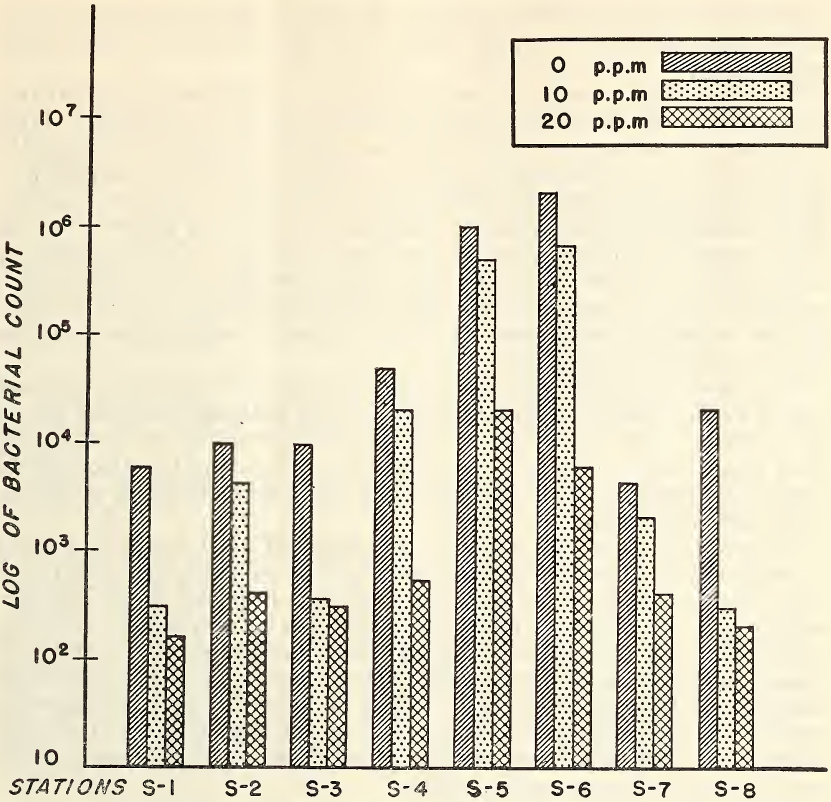

FIGURE 8.—Graphic comparison of bacterial counts on equipment when chlorine concentrations of 0, 10, and 20 p. p. m. were used.

At station S–5, the inside walls of the equipment where the cavity of the bird carcass was washed were showered constantly by deflected water from the carcass. The water hitting the walls was not sufficient, however, to provide good washing action for them; therefore, the walls were heavily contaminated. This condition created a bad spot because the washing operator in releasing his grasp on the carcass often set it to swinging freely on the shackle, with the result that the bird brushed against the wall of the washer and the carcass was contaminated.

At station S–6 where the birds were checked for internal cleanliness, carcasses that had imperfectly removed lungs or kidneys were taken from the shackles and placed on a table for reworking. The table did not have water running over it and the result was that very high bacterial counts existed on the tabletop. Reworked carcasses became very highly contaminated at this point.

Equipment sampling gave additional evidence of chlorine effectiveness in lowering levels of bacteria. Figure 8 shows bar graphs plotted from the data obtained by sampling equipment areas during processing at different concentrations of chlorine. At every station the bars are shorter at 10 p. p. m. than at 0 p. p. m. of chlorine, and at 20 p. p. m. the bars are shorter than those at 0 and 10 p. p. m. chlorine concentrations.

The bacterial counts for the water samples (table 3) were very great for 0 p. p. m., but the counts were much smaller for the chlorinated water runs.

The sampling along the eviscerating line disclosed the locations, or stations, where the sanitary quality of the eviscerated birds changed, and also how and why the quality changed. During the evisceration operations the bacteria and filth should be reduced progressively so that the carcasses reaching the last operation are in a state of high sanitary quality. Contrary to this, as noted from the data, many of the operations were responsible for large increases in the bacterial counts. Some of the reasons for these increases appear evident from the result of the tests and observations, and they constitute valuable indications of how ordinary improvements can be made in processing plants.

One means by which operations may be improved is by the increased use of water through sprays, flushing devices, and handwashing basins. Water, the most important vehicle in the scheme of sanitation, can do a great deal to minimize the possibility of recontamination of the carcass by washing away bacteria from equipment surfaces, tabletops, and hands of workers.

Another means of improvement is increased vigilance with respect to equipment. Proper installation and use of equipment and constant improvement of design will do much to improve operations necessary in poultry processing. Although such improvements are valuable in helping to maintain high sanitary quality of the poultry carcasses, the nature of the processing operations are such that additional sanitizing adjuncts are needed. The eviscerration-line sampling with and without chlorine gave results which proved conclusively that processing with "inplant" chlorination is far superior to processing without chlorine in the processing water.

Preliminary tests have shown—and reports from plants using inplant chlorination as a result of this work have substantiated the results of the tests—that unfrozen poultry carcasses which have been processed under chlorinated water conditions can be expected to have a shelf-life up to 9 days beyond that expected for poultry processed without chlorine.

By the time the processing operations normally falling between the eviscerating line and the cutting-up and packaging line were studied, the plant practice had been changed from cold to warm eviscerating with chilling after evisceration. The carcasses were removed after station E–11, weighed on a platform scale, put into appropriate weight-class tanks, and chilled.

The study of the transfer[4] operations showed that from the time the carcass was removed from the eviscerating line to the time it had been placed on the packaging-line shackles, the average bacterial count increased 119 percent—from 2,100 to 4,600 bacteria per square centimeter. The count increased 662 percent, from 2,100 to 16,000, during the weighing operation; fell 78 percent, to 3,500, during chilling by snow and water; and increased 31 percent, to 4,600, during the hanging of the carcass on the cutting-up and packaging line.

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[4] Transfer operations include removal from eviscerating-line conveyor, weighing, chilling, and hanging on the packaging-line conveyor.

Although the overall rise in bacterial count during the transfer operations was not excessive, it still represented a doubling of the count. It may be assumed that the rise would have been much smaller, or perhaps not present at all, had it not been for the weighing operation. This is a good example of how one operation can ruin the sanitary quality of the product.

The chilling operation proved to be cleansing, too, as may be observed from the 79-percent reduction in bacterial count resulting therefrom. The first reduction appeared to be somewhat large; therefore, two checks were made. Both checks were made during regular plant operation. Tagged carcasses were sampled and put into chilling tanks along with other carcasses. After chilling they were sampled again by swabbing. The first check resulted in a 92-percent drop in bacterial count, but a high initial count on the carcasses was suspected of distorting the result; therefore, another check was made. The second check consisted of samplings at intervals of 6, 12, and 24 hours. This test was conclusive—drops of 65, 69, and 81 percent, respectively, resulted.

The time element had been injected into the second test because it was thought that chlorine in the water could be credited with much of the action. A test was made for free chlorine in the chilling tanks. At the same time, bacteriological samples were taken of water drained from the tank.

Results in table 4 show that chlorine was utilized very quickly by the great amount of protein from the collected carcasses. The bacterial counts, at the same time, ranged in millions of bacteria per milliliter of drain water. It was evident, therefore, that although some of the action may have been caused by the chlorine, most of the bacterial reduction on carcasses was caused by the washing action and dilution by the chilling water.

TABLE 4.—*Residual chlorine utilization during specified times in which chilling water contacted the carcasses*

Contact time (minutes)	Chlorine concentration	Contact time (minutes)	Chlorine concentration
	Parts per million		*Parts per million*
0 [1]	20. 0	45	1. 5
1	5. 0	60	. 1
15	3. 5	90	Trace
30	2. 5	120	0

[1] As water was being filled into the tank.

The cutting-up and packaging line study, which consisted of two determinations, gave two sets of data which are summarized in tables 5 and 6.

The first set of data (table 5) comprises a determination of the total count change between the beginning and end of the processing line. The figures for each part of chicken are averages of counts obtained from the parts, or pairs of parts, from 10 chickens sampled within a run. The "before" figures are averages of bacterial counts

from parts of whole birds selected at the beginning of the line and aseptically segmented; and the "after" figures are averages of counts from parts of chickens from the same lot that had been cut up and packaged during regular plant operation. The counts are given in units of numbers of bacteria per milliliter of water in which the part was shaken.

In two runs, the average counts for each part declined, indicating a decontaminating action through the operations. The totals of the average parts' counts, representing the average bacterial count for whole chickens segmented, show that in the first run the count fell from 6,304,000 to 2,798,000, a drop of 56 percent; and in the second run the count fell from 4,330,000 to 2,120,000, a decrease of 51 percent.

Table 5.—*Comparative average bacterial counts on chicken parts before and after cutting-up and packaging operations*

Chicken part	Bacterial count per milliliter of water for [1]—			
	Run No. 1		Run No. 2	
	Before	After	Before	After
	Number	*Number*	*Number*	*Number*
Drumsticks and thighs [2]	1, 230, 000	858, 000	723, 000	436, 000
Wings	966, 000	646, 000	462, 000	440, 000
Back	1, 138, 000	712, 000	1, 303, 000	602, 000
Breast	2, 970, 000	582, 000	1, 842, 000	642, 000
Whole chicken (total parts)	6, 304, 000	2, 798, 000	4, 330, 000	2, 120, 000

[1] Number of bacteria in each milliliter of water in which chicken parts were shaken.
[2] Drumsticks and thighs were not separated.

The second set of data (table 6) was compiled from a determination of the count changes on parts before they were placed into conveyor pans and after they were packaged. The "before" figures represent the count on one part of respective pairs at the time it was cut away from the hanging carcass, and the "after" count represents the count on the other part of respective pairs after it had been carried in the conveyor pan with other parts to the packaging operations and had been packaged.

In all three runs there was evidence of both contaminating and decontaminating actions. The total for all the parts, however, still showed that a decontaminating action had taken place on the cutup chicken. The totals for the first run showed a count change from 51,800 to 39,300, a 24-percent decrease; for the second run a count change from 1,665,000 to 1,352,000, a decrease of 20 percent; and for the third run a count change from 4,263,000 to 915,000, a decrease of 79 percent.

Therefore, both determinations and all runs gave evidence that the cutting- and packaging-line operations were responsible for the lowering of bacterial counts on chicken carcasses being cut up and pack-

aged, even though wide variations existed in degree of contamination and contamination change.

TABLE 6.—*Average bacterial counts on parts of cutup chicken, before the parts were carried in conveyor pans and after being packaged*

Chicken part	Bacterial count per milliliter of water for [1]—					
	Run No. 1		Run No. 2		Run No. 3	
	Before	After	Before	After	Before	After
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Drumstick	4, 700	3, 200	7, 000	31, 000	[2] 111, 000	[2] 116, 000
Thigh	4, 800	8, 900	48, 000	89, 000		
Wing	8, 100	8, 400	289, 000	214, 000	178, 000	51, 000
Back	13, 400	13, 500	439, 000	446, 000	1, 974, 000	218, 000
Breast	20, 800	5, 300	882, 000	572, 000	2, 000 000	530, 000
Whole chicken (total parts)	51, 800	39, 300	1, 665, 000	1, 352, 000	4, 263, 000	915, 000

[1] Number of bacteria in each milliliter of water in which parts were shaken.
[2] During run No. 3 the thigh and drumstick were not separated.

Tests performed to determine how the decontaminating action was taking place showed that the conveyor pans, which were automatically washed by strong sprays of chlorinated water after each circuit of the line, had a negligible count at the beginning of the circuit and a very high count after the last part of cutup chicken had been removed. Bacteria were transferred by contact, from the more highly contaminated chicken parts to the less contaminated pan. In addition, there was a decontaminating action due to the handling of the chicken carcass by the workers. The workers who cut the parts away washed their hands very frequently to give them a good grip on the carcass during cutting. Inadvertently, they were improving the condition of the carcass by removing bacteria through the tendency toward transfer of bacteria to less contaminated surfaces from more contaminated areas. Swab samples showed that bacteria on hands of operators, after washing, ranged from 100 to 1,000 bacteria per square centimeter, whereas the bacteria count from unwashed hands ranged from 10,000 to 200,000 per square centimeter.

The fact that the particular method of segmenting carcasses from the conveyor onto low-count pans did not increase the bacterial numbers is important, because it indicates that improved procedures for decreasing the bacteria along the dressing, eviscerating, and transferring operations can result in cutup chicken of higher sanitary quality in the package. This, however, is possible only if constant vigilance is practiced during cutting and packaging.

From the studies and observations conducted along the different lines during processing, the conclusion is that improvements are possible and desirable in the operations ordinarily carried out in poultry-processing plants. Improvements that help to maintain a highly

sanitary plant and operations can be expected to raise the sanitary quality of the processed poultry as measured by bacterial numbers on the surface of the product. Among the improvement methods, inplant chlorination stands out. Although chlorination cannot be expected to supersede other sanitation procedures or vigilance by the plant operator, chlorine in the processing water does effect better sanitation throughout the plant and it improves the sanitary quality of processed birds.

Other sanitary methods intended for improving the sanitary quality of processed birds at specific operations are reported under the following headings.

Chlorinated Snow

Artificial snow made from water containing 20 parts per million of chlorine cannot be expected to exert any greater sanitizing action than ice made from unchlorinated water, because counts on New York dressed and eviscerated groups of birds in all four tests using chlorinated ice showed both increases and decreases in bacterial counts. Neither the increases nor the decreases followed any set pattern except that the level of initial and final counts of bacteria was lower on the eviscerated birds processed under chlorinated water than was the level of counts on all others.

The reason for the lack of increased sanitizing properties was evident after the occluding capacity for chlorine by artificial snow was tested. It was noted that at the time the snow was manufactured, chlorine was concentrated in the unfrozen phase and this was trapped between crystals of ice. As soon as the snow fell into the storage bin, the drain water migrated to the bottom, taking with it the chlorine.

Measurements of the chlorine content of snow taken from the top, middle, and bottom of containers in which snow had been collected as it fell from the cylindrical freezer, indicated the above-mentioned action. Results of five tests showed that the highest concentrations in the snow were those sampled immediately after the snow was manufactured. At that time all three sampling locations—top, middle, and bottom of the collection tanks—had a concentration of 5 parts per million of chlorine. After 30 minutes the concentration had fallen in the top part of the tank to 1.5 p. p. m., in the middle part to about 4 p. p. m., and the concentration stayed at 5 p. p. m. in the bottom part of the tank. The drainage water at this time measured 15 p. p. m. The chlorine residual fell constantly until no chlorine could be detected in the top part of the tank after 2.5 hours, in the middle portion after 4.25 hours, and in the bottom part of the tank after 8 hours. The drain water maintained a concentration of about 10 parts per million of chlorine for 8 hours, but contained no chlorine after 24 hours.

It appears possible that a slight sanitizing action might be obtained from chlorinated snow if it were used immediately after manufacture, but snow accumulated overnight in bins would lose most of the chlorine in the drain water.

Mechanical Washing After Evisceration

Results for three test runs of mechanical washing with one of the older model washers are shown in table 7. In all three runs, the mechanical washer was much more efficient than was the spray washer.

The percentage decreases in numbers of bacteria on chicken carcasses washed with the scrubbing action of the mechanical washer ranged from 90 to 97 percent, whereas on chicken carcasses washed by sprays alone the decrease was between 59 and 78 percent.

Important data in table 7 are those showing the levels to which bacterial contamination were lowered. Final counts ranged from 300 to below 2,700 for mechanical washing and above 4,500 to 7,000 for spray washing, regardless of what the initial counts were.

Test runs on the improved mechanical washer were begun immediately after this washer was set in place. The tests were made only on the mechanical washer—no comparison counts having been made at the spray washer. The first run resulted in a surprising 5.6-percent increase in the number of bacteria on the chicken carcasses. An inspection of the machine showed that the plant pipe supplying water to the machine supplied too many other operations and as a consequence the quantity of water available to the washer was small. Also, the supply pipe was smaller than the machine pipe connecting to the spray jets. Thus, the spray action was reduced to small streams of water. As in the case of the finisher on the dressing line described earlier, the rubber fingers spread contamination because there was not enough water for washing action.

TABLE 7.—*Comparative average bacterial counts on chicken carcasses before and after washing by means of mechanical and spray washers*

Test run (No.)	Bacterial count per square centimeter from—					
	Mechanical washer [1]			Spray washer		
	Before	After	Percentage decrease	Before	After	Percentage decrease
	Number	*Number*	*Percent*	*Number*	*Number*	*Percent*
1 [2]	11, 200	300	97	12, 000	5, 000	58
2 [3]	29, 600	2, 700	91	19, 000	7, 000	63
3 [3]	22, 000	2, 300	90	23, 000	4, 500	80

[1] Old model mechanical washer; no inside wash.
[2] Randomly selected carcasses.
[3] Selected dirties.

The second run was made after an improved supply of water was provided to the machine. Before the run was made, the machine was inspected and it was found that at least half of the jets were partially or completely blocked with waste matter. The run was completed with the machine in this condition as a check on the sanitary quality that might be expected when machines are poorly maintained. As expected, the efficiency of the machine was considerably lowered as only a 47-percent drop in bacterial count resulted.

The third run was made immediately after the second run, but not until the jets had been cleaned and were in good working order. The bacterial count on the carcasses being washed with the machine in proper operating condition was lowered by 94 percent. The carcasses

washed mechanically were visibly much cleaner and fresher looking than were the spray-washed carcasses.

The evidence obtained in those runs proved that mechanical washing is far superior to spray washing. At the same time, however, the evidence showed that equipment, such as the mechanical washer, can be a danger point if improperly installed or poorly maintained.

The inside, or visceral cavity, washing feature of the improved mechanical washer proved to be a valuable adjunct. Differences in average "before" and "after" bacterial counts amounted to a 47-percent decrease in number of bacteria in the visceral cavity from the use of this equipment.

It was found that for proper operation the eviscerated carcasses had to be hung by the wing rather than by the leg before they were passed through the mechanical washers. Eviscerated carcasses hung by the leg were ripped along the ribs by the pulling action of the rubber fingers.

Chemical Dip

The chemical sanitizer used as a dip was effective, as shown in table 8, in reducing the number of bacteria on chicken carcasses without affecting the appearance of the carcass. The dip reduced bacterial counts from a mean of 38,530 to one of 5,890 per square centimeter—a reduction of 85 percent.

TABLE 8.—*Bacterial counts on surfaces of chicken carcasses before and after dipping in chemical germicides*

Sample	Bacterial count		Sample	Bacterial count	
	Before dipping	After dipping		Before dipping	After dipping
	Number	*Number*		*Number*	*Number*
1	80, 000	6, 000	7	26, 000	2, 700
2	13, 000	2, 300	8	20, 000	3, 300
3	130, 000	11, 000	9	60, 000	200
4	25, 000	1, 900	10	15, 000	7, 000
5	4, 300	20, 000			
6	12, 000	4, 500	Average	38, 530	*5, 890

*Employing Fisher sign test $P=0.02$.

The sanitizing value represented by such a reduction provides evidence that the chemical dip may be useful, but not until improvements are made in the chemical products. To obtain the 85-percent reduction, the chemical was used at a concentration of 1,000 parts per million. The amount of the chemical necessary to provide such a high concentration and the dipping time necessary for disinfection would make its use in commercial operation difficult, because equipment and space requirements would be excessive. Continuous dipping would require a trough 170 feet long to allow the chicken carcasses traveling the conveyor at 17 feet per minute a 10-minute dip, the time during which the observed reduction took place. The same percentage reduction was obtained by the use of 20 parts per million of chlorine in

water at station E–11 during the comparison of sanitizing effects of processing water containing 10, 20, and 45 p. p. m. of chlorine.

Ultraviolet Radiation

The nonpenetrating ultraviolet radiation from ozone- and non-ozone-producing tubes proved effective for lowering bacterial counts on eviscerated chickens by 35 and 54 percent, respectively (table 9). No conclusions concerning differences in the bactericidal effect obtained from the two types of tubes could be drawn from the limited tests. Greater decreases can be noted, however, from increased exposure time of 26 and 39 minutes. Final counts may be indicative of the level to which bacterial counts can be lowered, as in these limited tests the lowest counts ranged between 12,000 and 15,000 bacteria per milliliter of water in which half of a chicken was shake sampled.

TABLE 9.—*Comparative average bacterial counts on chicken carcasses before and after treatment with ultraviolet ray*

Treatment (number)	Exposure time	Bacterial count per milliliter of processing water with [1]—					
		Non-ozone-producing tubes			Ozone-producing tubes		
		Before	After	Percentage decrease	Before	After	Percentage decrease
	Minutes	*Number*	*Number*	*Percent*	*Number*	*Number*	*Percent*
1	13	294, 000	135, 000	54	23, 000	15, 000	35
2	26	267, 000	23, 000	91	35, 000	12, 000	66
3	39	122, 000	15, 000	88	17, 000	12, 000	29

[1] Number of bacteria in each milliliter of water in which halves were shaken.

In the tests of radiation effects on skin surfaces, there were noticeable changes in the texture of the skin after 30 minutes of exposure. The skin of treated fowl halves was tanned, had a slight singed odor, and felt leathery in comparison with that of untreated controls. After 36 minutes, the leatherlike appearance was more pronounced and there were signs of fat seepage. Broiler halves, on the other hand, except for having a slight singed odor, were not otherwise affected even after 120 minutes of exposure to radiation. Halves held at refrigerated temperatures showed no delayed, deleterious reactions; rather, the treated halves looked better than did the untreated halves because the cut meat of the treated halves did not look dehydrated and no drip was found in the package. The tanning which had been noticeable on halves treated for 29 minutes disappeared, and tanning was lessened considerably on the 59-minute-exposure halves. Exposed tissue parts appeared drier—as though they had been cauterized along the cut cells—immediately after exposure. Blood was not visibly changed.

Results of these tests indicated that it may be possible to use ultraviolet radiation as an adjunct to other sanitizing methods in processing operations such as those performed along the segmenting and packaging line. More research is needed, however, to determine the most

effective types of installations and methods for using ultraviolet rays. Ultraviolet rays having wavelengths within the bactericidal range are not penetrating and they cannot be expected to sterilize processed poultry; nor can ultraviolet rays be expected to effect germicidal action wherever water, fat, or waste matter covers the surfaces to be treated. It is evident then that the germicidal action of the rays lends itself only to the operations in which the chicken carcasses are free of adhering materials, water, and loose cuticle, and in which a dry form of germicidal action is needed. In poultry processing, ultraviolet could best be utilized during the packaging operations in which a last sanitizing treatment before the bird is put into the package could be expected to give the bird a higher sanitary quality.

CONCLUSIONS

1. Dressing, eviscerating, and cutting-up operations as practiced in most plants can be expected to lower the bacterial count which is ordinarily very large on carcasses after killing the birds and removing the feathers.
2. A progressive decrease of bacteria on poultry surfaces should occur after the first eviscerating operation. Bacterial counts should not suddenly rise from low to high numbers.
3. Ordinary improvements can be made in the processing procedures and sanitation practices of typical commercial poultry plants. Such improvements will raise the sanitary quality of processed poultry.
4. Water flushing should be used, wherever possible, to wash away bacteria.
5. Equipment should be inspected periodically to make sure that it is installed correctly and maintained in the best possible working condition.
6. Hand-washing facilities should be provided wherever the bird is handled.
7. Birds should not be allowed to touch or brush against surfaces of equipment. Surfaces which birds must touch should be water flushed.
8. Inplant, breakpoint chlorination at 10 to 20 p. p. m. will provide additional sanitizing action that will raise the sanitary quality of the bird, improve the sanitary condition of the equipment, eliminate slime and corrosion from equipment and the floors, eliminate plant odors, and help to maintain water pipes and keep jets free from accumulated scale and debris.
9. Chlorinated water will not freeze into a eutectic-type chlorinated snow. The chlorine is frozen out. The snow cannot be expected to exert any greater sanitizing action than snow made from plain water.
10. Mechanical washing as a last operation on the evisceration line is an exceptionally good expedient for cleaning adhering foreign material such as crop material and feces from the surfaces of the carcasses, and it decreases the numbers of bacteria on the surfaces of poultry carcasses. The mechanical-washing machine must be installed and operated correctly with sufficient water to wash the rubber fingers and carcasses; otherwise the fingers will become contaminated by bacteria which will raise the bacterial counts on the carcasses.

11. A proper chemical germicide used as a dip can be expected to lower the bacterial numbers on poultry carcasses, and the chemical would provide a good means for lowering the numbers of bacteria on eviscerated birds. More work must be done to provide poultry processors with a chemical that is faster acting than the one tested—a chemical that is nontoxic, economical to use, and that does not leave a residue.
12. Ultraviolet radiation lowers bacterial counts on chicken carcasses without detrimental effects to the skin and flesh surfaces. It shows promise as a method for use in operations just before packaging, in which a dry form of sanitizing action would lower the bacterial numbers even more and assure high sanitary quality of the bird.

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